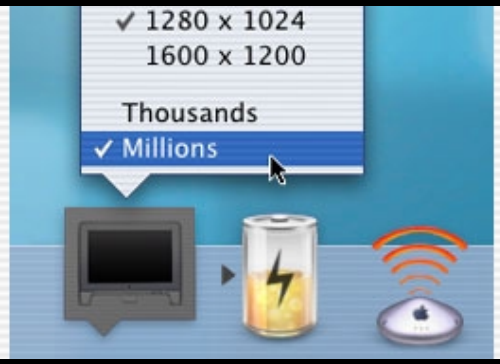
Session 103

Darwin Overview:
The Foundation of Mac OS X



Brett Halle
Director, Core OS Engineering

What Is Darwin?

- Darwin IS the Core OS of Mac OS X
- Open source!

What Is the Core OS?

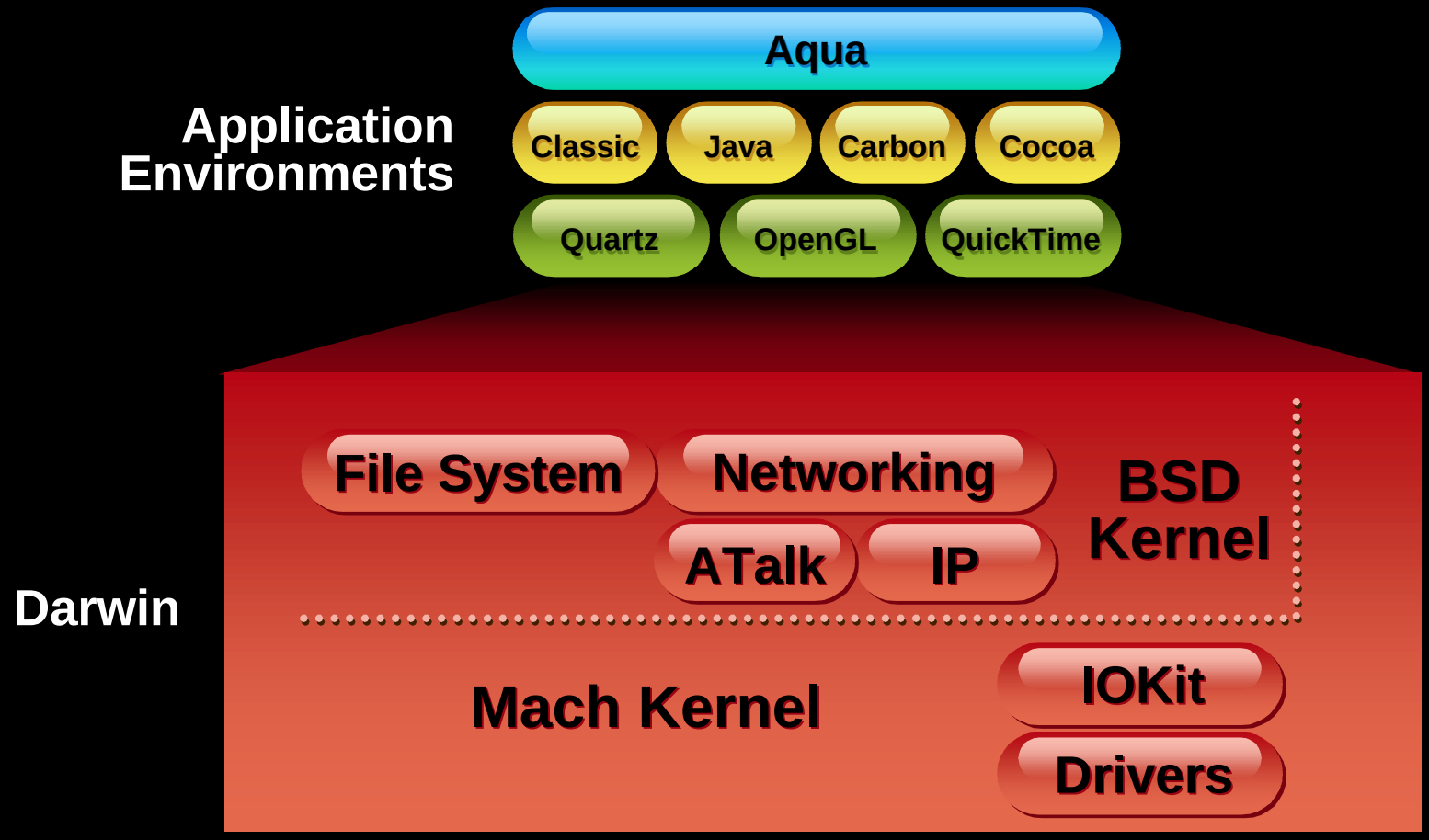
Darwin/Core OS

- Unique architecture
  - Built from multiple best-of-class technologies
- Based on proven technology
  - Hundreds (probably thousands) of man-years invested in development and testing
- Tuned for Apple's customer base
- Lots of untapped potential
  - We are enabling the next killer apps

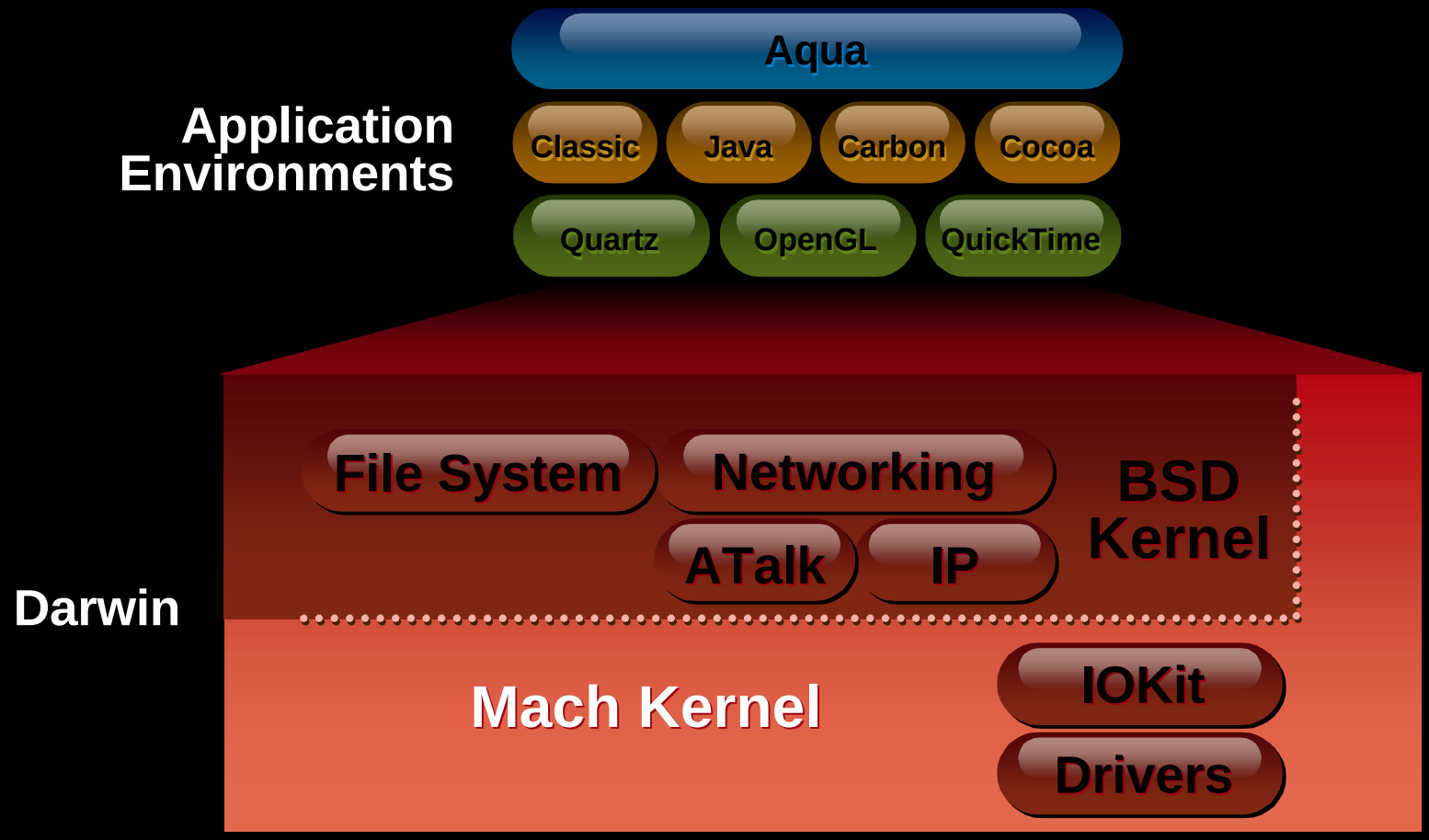
Darwin/Core OS

- Provides preemption and protection
- Multiple address spaces
- Supports the application environments
- Device independent
- Flexible
- Scalable
- Completely buzz-word compliant!

Darwin/Core OS



Mach Kernel


Application Environments
Aqua
Classic
Java
Carbon
Cocoa
Quartz
OpenGL
QuickTime
Darwin
File System
Networking
ATalk
IP
BSD Kernel
Mach Kernel
IOKit
Drivers

Mach: OS Foundation

- Manages processor and memory resources
  - Processor scheduling
    - Threading is an integral kernel service
  - Memory protection, memory management
- Message based architecture (IPC/RPC)
- Policy neutral
- Mach does not provide:
  - I/O, Networking, File Systems, Security Policy, Application APIs, etc.

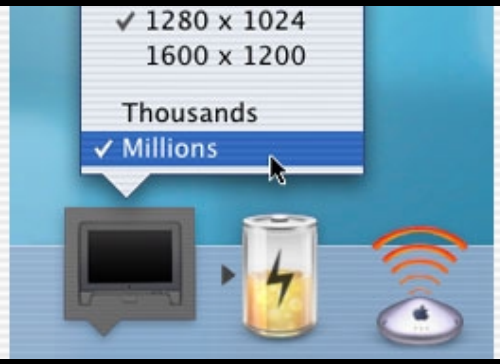
Mach

- Mac OS X: Based on Mach 3.0+
  - Derived from CMU and OSF/RI Mach 3.0 work
    - Plus tons of work by Apple
  - Architectural support for SMP/real-time
  - Multiple scheduling policies
  - External pager
  - Modular architecture

Application View of Mach

- All process models are built on top of Mach primitives
  - Tasks and Threads
- All memory management is built on top of Mach primitives
  - VMObjects, virtual memory, paging
- Kernel to User and User to User communication is built on top of Mach primitives
  - IPC & RPC, “ports”

Demo



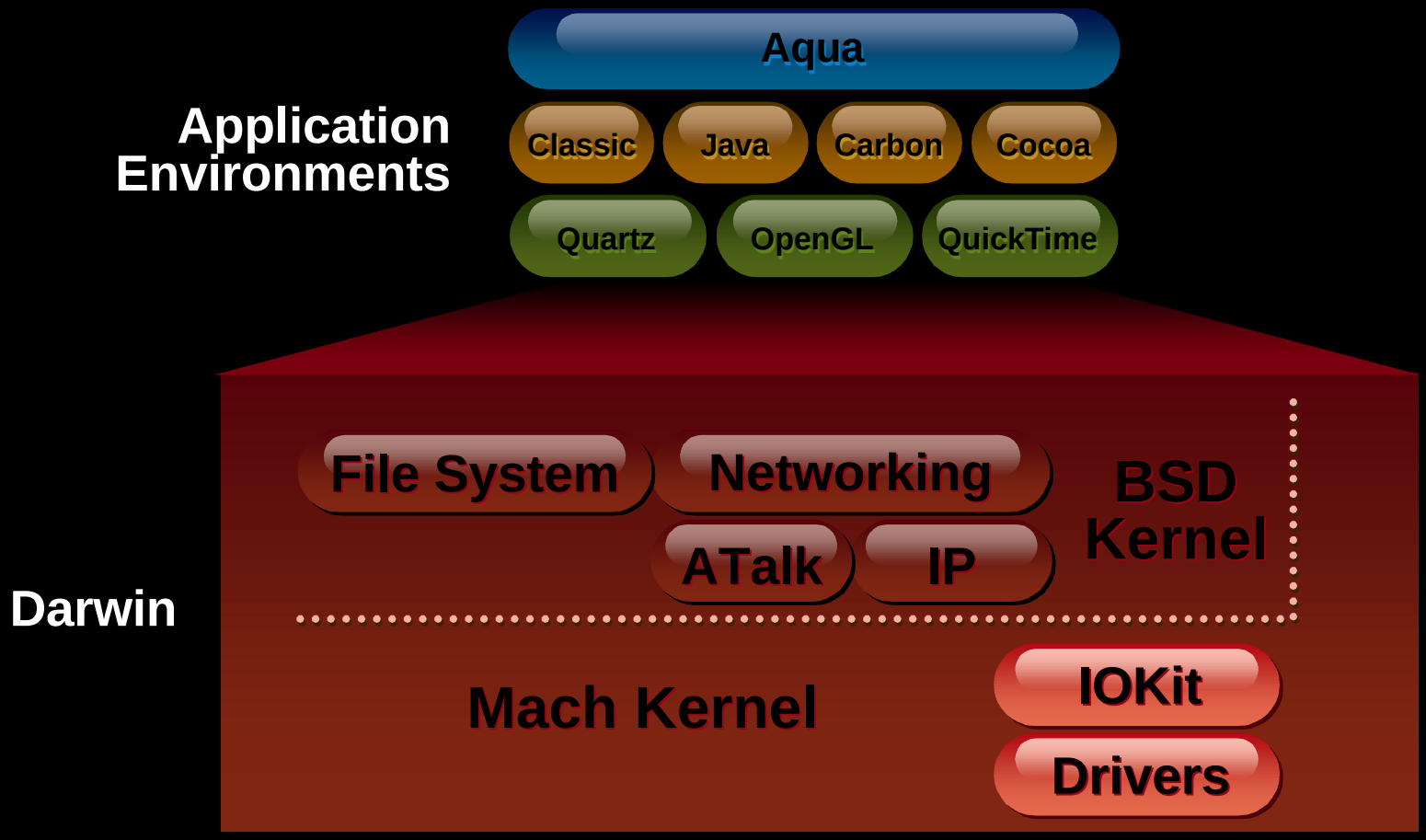
Joseph Sokol, Jr.
Manager, Core OS Performance Group

Roadmap

140 The Darwin Kernel

Civic
Fri., 3:30pm

I/O Kit and Drivers



I/O Kit

- Object-oriented framework for easy development of device drivers
  - True plug-and-play
  - Dynamic device management
  - Power management
  - Modular and extensible
- Provides abstractions for most device classes
  - Mass storage, SCSI, ATA, USB, FireWire, Audio, Network, PCI, etc., etc.

I/O Kit Features

- I/O Kit is a framework
  - Provides common kernel services for I/O
    - User/Client model
  - Models physical world
  - Handles driver matching
- Protocol specifics are in Families
  - For example: SCSI versus Audio
- Device specifics are in Drivers
  - Access to the hardware

Power Management

- Integral to I/O Kit architecture
- Based on the concept of power planes
- Wake up is done in parallel and eliminates as many serial dependencies as possible

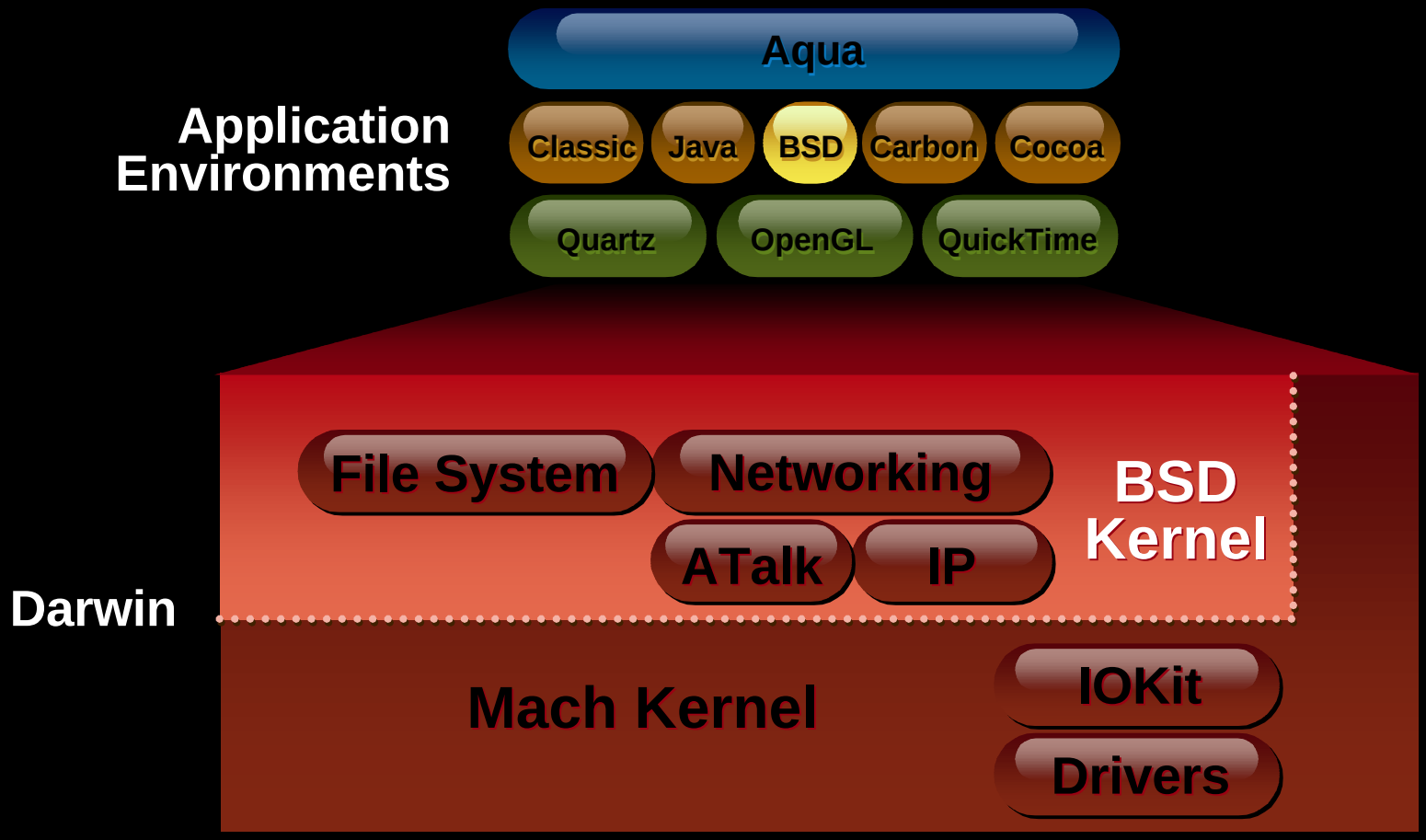
I/O Kit and Applications

- Most devices are hidden behind other OS abstractions
  - Disks: file systems
  - Networking: IP
  - Input devices: events
- User clients exist when applications need device access
  - USB
  - HID Manager

Roadmap

104 I/O Kit Update	Room A1 **Mon., 3:30pm**
202 FireWire Overview	Room A2 **Tues., 2:00pm**
203 USB Overview	Room A2 **Tues., 3:30pm**
204 I/O Kit: Storage Drivers	Room A2 **Tues., 5:00pm**
205 I/O Kit: PCI Drivers and Open Firmware	Room C **Wed., 9:00am**

BSD: The Power of UNIX

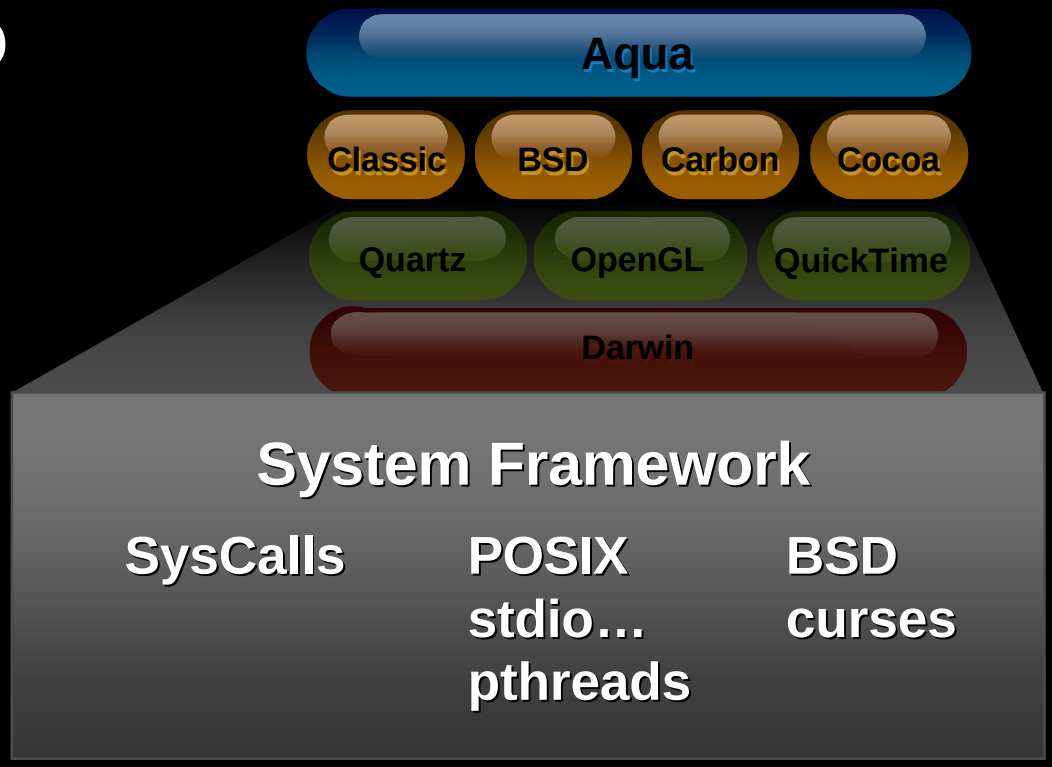


BSD Kernel

- Based on BSD 4.4
  plus integration with Mach and I/O Kit
- Provides “OS Personality” APIs and Services
  - Process model
  - Basic security policy
  - File system architecture
  - Networking architecture

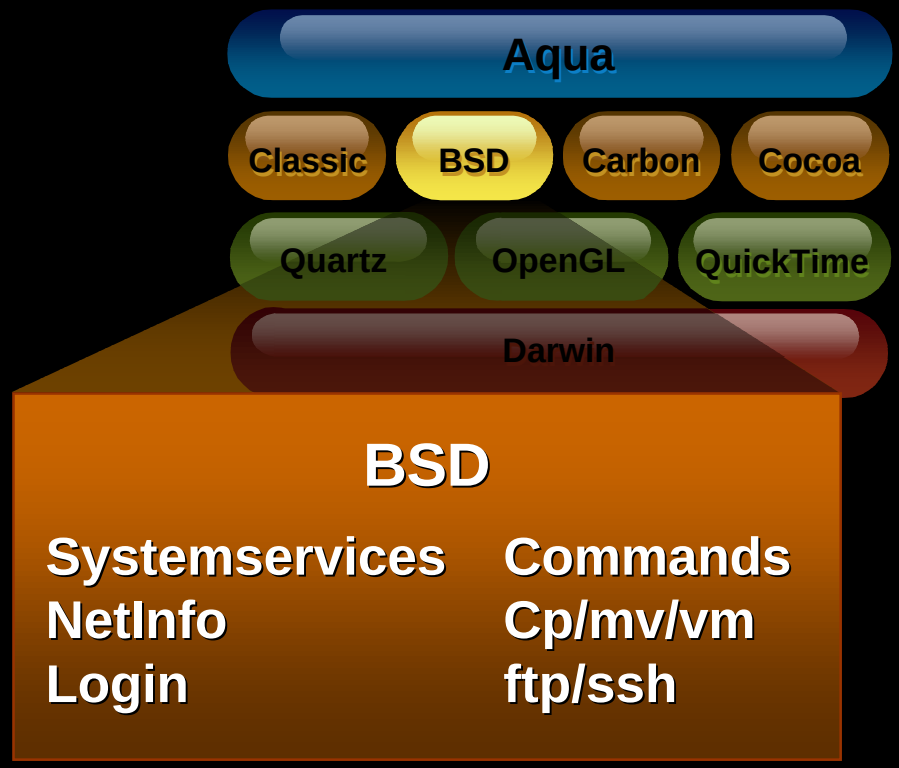
System Framework

- Exposes "POSIX"/BSD System APIs
- Additional services:
  - pthreads
  - Math library
  - C library



BSD User Environment

- Command line/shells
- Network client tools
  - ssh, finger, ftp
- File tools
  - cp, ls, mkdir
- System tools
  - ps, kill, top, shutdown
- System services
  - NetInfo, DNS/BIND, NTP, syslog, Apache



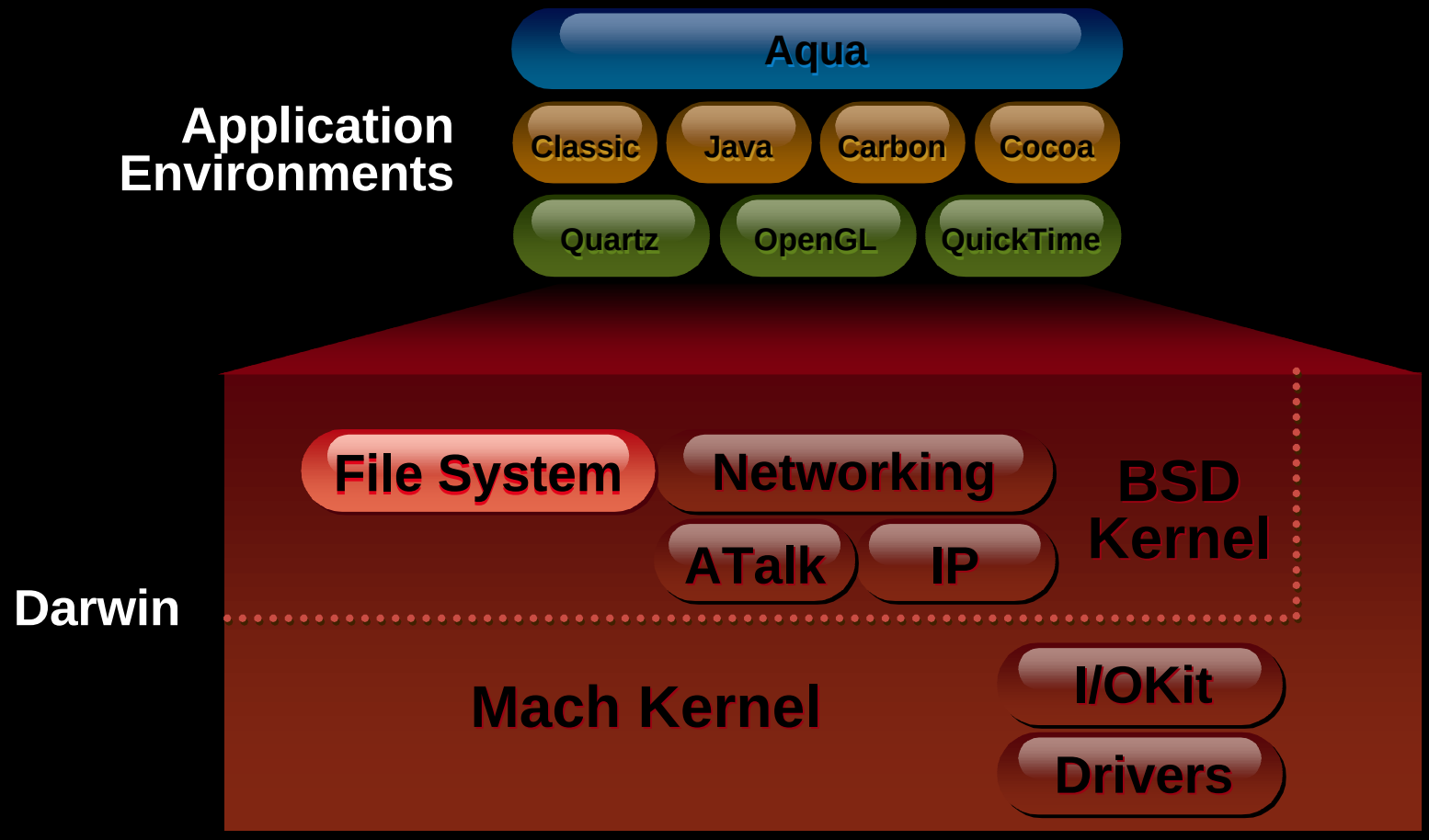
BSD and You

- Process model
  - Environment variables, signals
- Security
  - Users, file system access
- A developers perspective…tools, tools, tools
- Porting UNIX applications to Mac OS X
- Using UNIX tools from within a GUI application

Roadmap

139 Leveraging BSD Services in Mac OS X	Civic **Fri., 2:00pm**
201 How Threading Can Benefit Your Application on Mac OS X	Room A2 **Tues., 9:00am**
302 Directory Services	Room A1 **Tues., 3:30pm**

File System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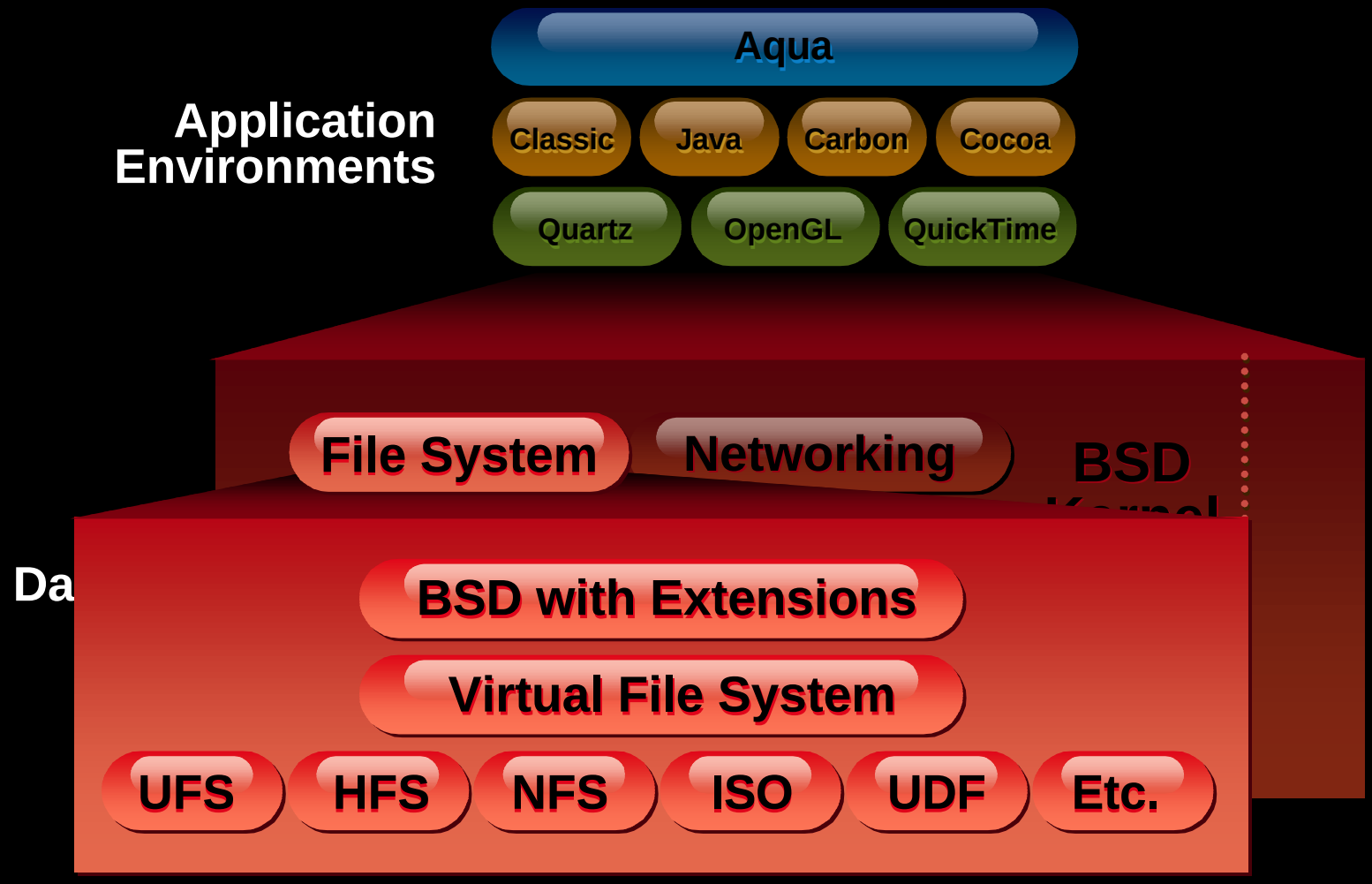
Drivers

File System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Cocoa
Quartz
OpenGL
QuickTime
File System
Networking
BSD
Da
BSD with Extensions
Virtual File System
UFS
HFS
NFS
ISO
UDF
Etc.

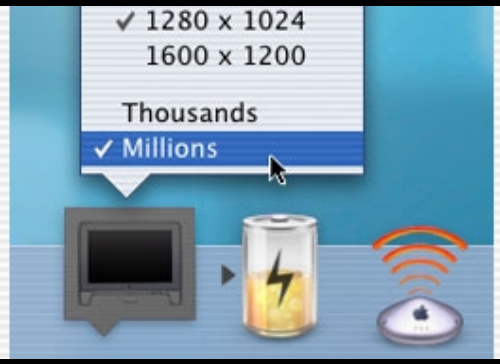
File System

- Component of the BSD kernel environment
- Enhanced VFS design
  - POSIX++ interface
  - Layered architecture (stackable)
- Can support numerous file system types
  - HFS, UFS, ISO 9660, FAT, AFP, NFS, WebDAV, UDF, AFS, etc.
- UTF-8 interfaces
- No specific file system affinity

File System

- Enforces file security policy
  - Users, groups, access control
- Application environments provide abstracted interfaces
  - Carbon: File Manager
  - Cocoa: NSFile
  - BSD: Posix++

Demo



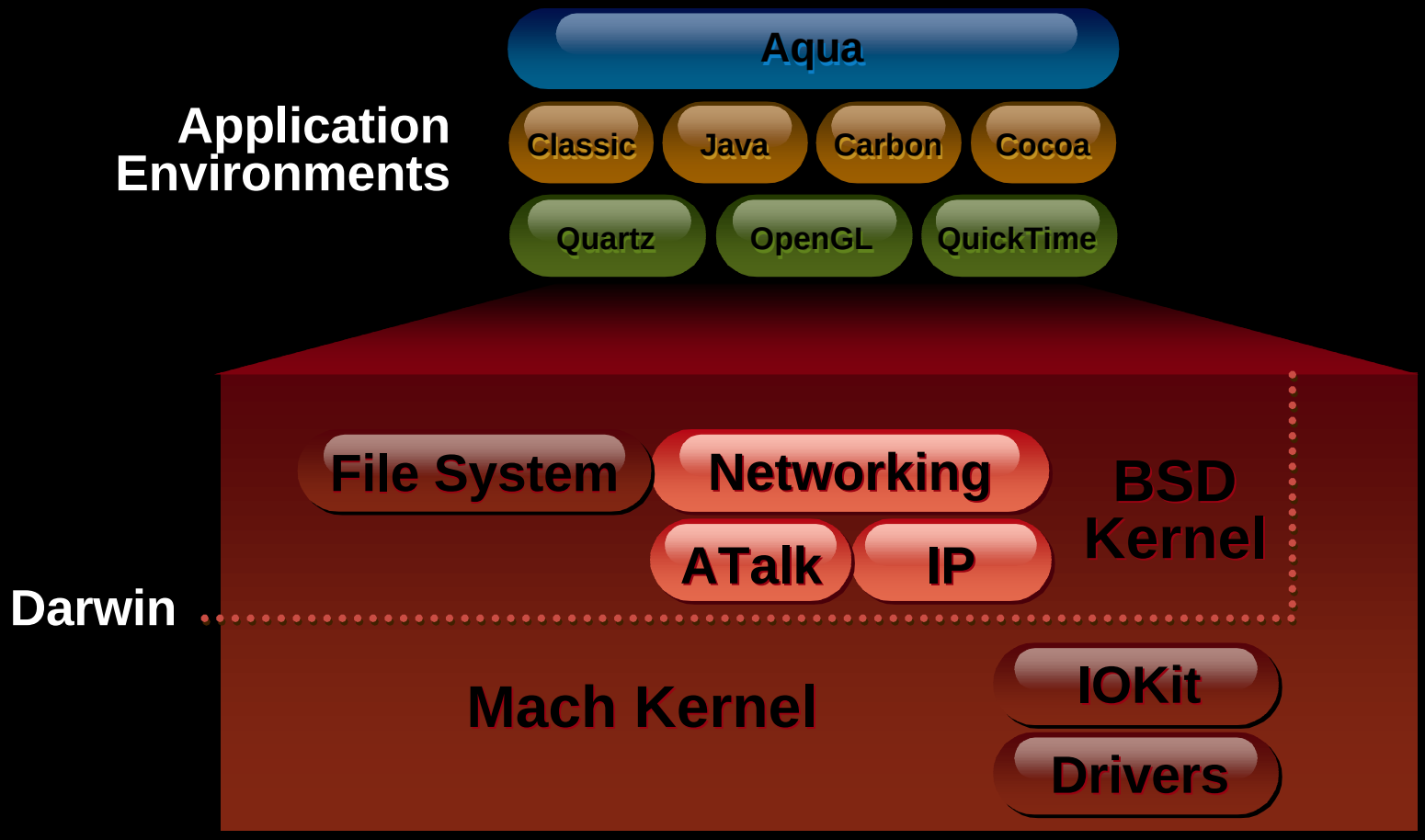
Joseph Sokol, Jr.
Manager, Core OS Performance Group

Roadmap

116 Mac OS X File System

Room J2
Wed., 9:00am

Networking in Mac OS X



Networking

- Component of the BSD kernel environment
- BSD 4.4 TCP/IP Stack (sync'd with FreeBSD 3.2)
  - Socket APIs
- Key features:
  - IPv4 Multi-homing
  - Full IPv4 routing
  - Firewall and NAT mechanisms
- Auto configuration

Networking

- Kernel Extensions for Networking
- Classic support: Shared IP
- Open Transport in Carbon
- PPP, PPPoE
- DHCP client, server
- Ad hoc networks

Mobility

- Flexible architecture
- Auto (re)configuration
  - Link level detection
  - Dynamic
- Multiple configurations
- Application notification

Roadmap

300 Networking Overview	Room A1 **Tues., 9:00am**
304 Extensible Kernel Networking Services	Room J2 **Tues., 10:30am**
303 Network Configuration & Mobility	Room A1 **Tues., 5:00pm**
FF107 Feedback Forum: Networking	Room J **Thurs., 10:30am**

Core OS and G4

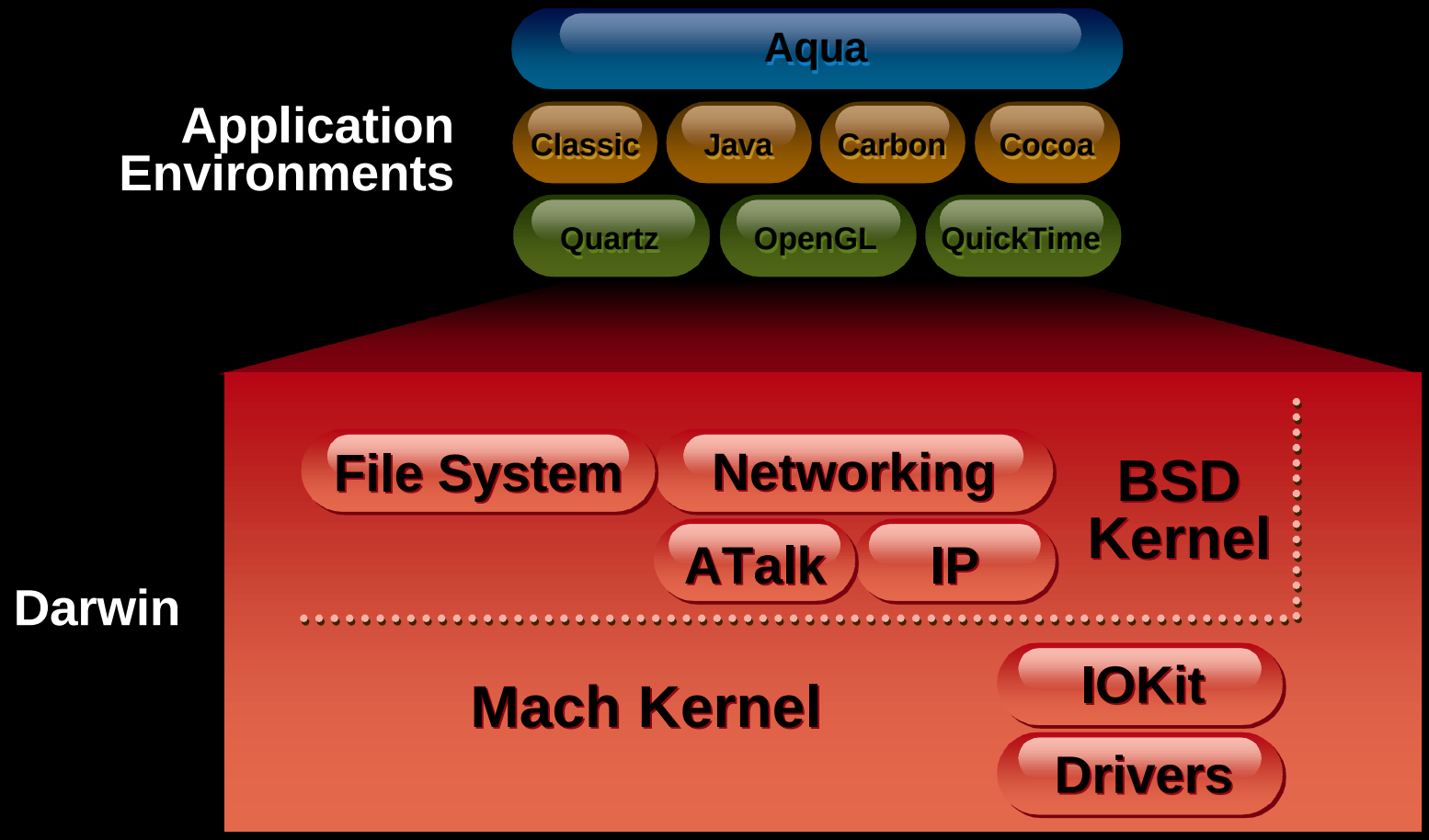
Velocity Engine

- Vector libraries (vecLib framework)
  - vDSP: fast digital signal processing functions, including FFTs and convolutions
    - On Mac OS 9.1 and X
  - vBLAS: vector Basic Linear Algebra Subroutines, including matrix operations, used for MP3, mpeg, speech, image processing
    - Only available on Mac OS X
  - Matrix multiplies on 500mhz G4: 2.2 gigaflops!
  - vMathLib, vectorOps, vBasicOps and vBigNum

Multi-Processor G4's

- Mac OS X supports true SMP
- Each thread can run on a separate processor
  - Use MP APIs for Carbon
  - NSThread for Cocoa
  - pthreads for BSD apps
- Mach, BSD, and SMP…

Kernel Extensions



Kernel Extensions

- A code-fragment container for kernel binaries
  - I/O Kit Drivers
  - Network Kernel Extensions (NKEs)
  - File System plug-ins
- Mac OS X KEXT ≠ Mac OS 9 Extension
- Only if you have to…

Kernel Extensions

- Mac OS X Kernel plug-in model
- KEXTs are bundles that contain:
  - Property List in xml
  - A binary for use in the kernel (KMOD)
- KEXTManager auto loads/unloads
- Manual tools, too
  - Kextload, kmodload, knodunload, kmodstat

Kernel Extensions

- Each KMOD has two entry points
  - Initialize, called on load
  - Finalize, called just before unload
- All other APIs are domain specific
  - I/O Kit Drivers
  - Network Kernel Extensions (NKEs)
  - File System Plug-ins

Developing Inside the Kernel

- Two-machine debugging
- Limited language features
- No direct user interaction
- Resources are more costly
- Failures are fatal

Darwin and Open Source

- Virtually all Core OS components are available as open source
- Code is fed back to up-stream providers
  - FreeBSD, Apache, etc.
- Cooperative community
  - Security fixes, platform fixes
- External developers can contribute to Darwin

Roadmap

115 Open Source at Apple	Room A2 **Wed., 10:30am**
Darwin BOF	Hall 2 **Tues., 6:30pm**

Final Things To Think About…

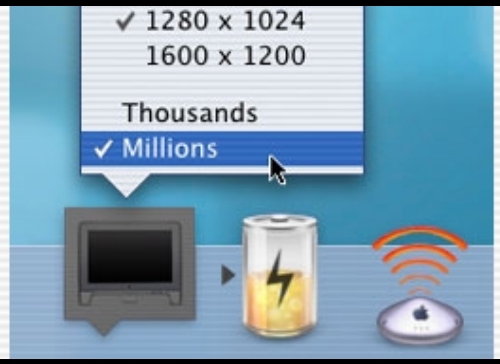
- BSD "UNIX" user experience hidden
  - Optional environment for power users and developers
- Don't repeat bad habits (e.g., shared memory)
- You need to have a "systems" view
- Use highest level of abstraction possible
- Open source is a powerful tool
  - Get involved in Darwin open source!
- There is enormous potential here…

Roadmap

FF121 Feedback Forum: Darwin

Civic
Fri., 5:00pm

Q&A



Jason Yeo
Core OS Technology Manager
jason@apple.com

http://developer.apple.com/events/urls.html

WWDC

Worldwide Developers Conference 2001